

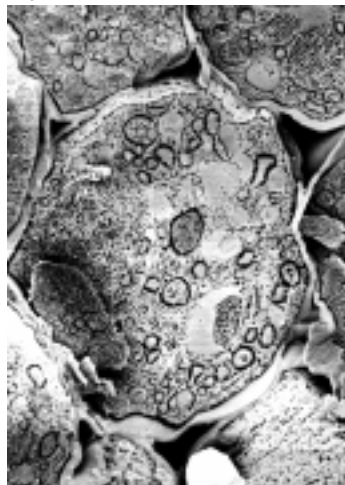
# Winterfat Seeds Take Ice Stakes Through the Heart

**S**harp ice crystals in the seed embryo mean instant death for most seeds—but not for those of winterfat, a low-growing shrub that thrives from the Yukon to Mexico. ARS studies have shown that sopping wet winterfat seeds from Wyoming, Colorado, and Saskatchewan, Canada, can survive temperatures at least as low as  $-22^{\circ}\text{F}$ .

So how does this native seed of the spinach family do it? And, can this ability be transferred to major crops?

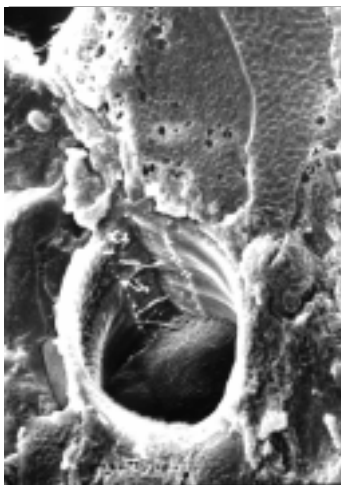
Terry Booth, a rangeland scientist with USDA's Agriculture-

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Magnified view of normal cells and tissue of a germinating winterfat seed at  $32^{\circ}\text{F}$ .

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When frozen, germinating winterfat seeds withstand formation of large ice crystals (seen as dark holes in this magnified view) and continue growth after thawing.

al Research Service in Cheyenne, Wyoming, is going to great lengths to find out. Most recently, he visited ARS cytologist William P. Wergin in Beltsville, Maryland, to look at the seeds through a scanning electron microscope specially designed to view frozen tissue.

Booth soaked and froze the seeds to simulate the West's freeze-thaw cycles. Particularly in the spring, seeds often get wet from snowmelt during the day and then, overnight, the water in the seeds turns to ice crystals. Or the seeds get wet and start sprouting during a warm spell, only to be frozen by winterlike spring storms.

Booth, working with Yuguang Bai, who is with Agriculture and Agri-Food Canada in Kamloops, British Columbia, and Jim Romo, with the University of Saskatchewan, found that water absorption before germination is greatest for seeds soaked at  $40^{\circ}\text{F}$  or lower. Most seeds have a greater risk of freezing damage as their water content increases.

Winterfat, however, often grew better when it had been

soaked at cold temperatures before freezing. Seedling vigor also varied by where the seeds were collected, indicating that the plants have evolved so that the germination requirements of the seeds fit local climate variations. "So it's generally best to plant seed collected locally," Booth says.

Under magnification, Booth saw ice crystals in the embryos of seeds that were frozen at  $-22^{\circ}\text{F}$  before being plunged into and stored in liquid nitrogen to preserve any internal ice crystals, as well as nearby tissue. What surprised him was that the tissue was freeze-dried, with only occasional large ice crystals and no indication of normal cellular structure.

"A key part of winterfat's tolerance to freezing seems to be its ability to hydrate, dehydrate, and rehydrate again without significant damage," Booth says.

That intrigues Booth because of his suspicion that winterfat may fight ice with ice. The hairy layers that cover winterfat seeds appear likely to promote ice crystal formation. If ice crystals form first in the outer layers, these crystals may suck water from the embryo, aiding a freeze-dehydration process that limits damage caused by embryo ice. It may keep the largest crystals out of the embryo.

"But we need to spend a lot of time analyzing photographs taken through the microscope before we can reach any conclusions," he says.

Booth finds the winterfat shrub's ice tolerance as interesting as that of the Antarctic nematode that is the only animal known to survive with ice in its cells.

But there is a very practical purpose to Booth's research. Winterfat is important as a food source for cattle in the western United States and as nesting cover for ducks on Canadian prairies. For the latter reason, Ducks Unlimited, Canada, funded part of the research. The U.S. Bureau of Land Management, the USDA Forest Service, and mining companies plant winterfat on degraded rangelands and strip-mined areas.—By **Don Comis, ARS.**

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Seeds of the winterfat plant, *Eurotia lanata*, can be harvested in October.